US009369344B2

(12) **United States Patent**
Datla et al.

(10) **Patent No.: US 9,369,344 B2**
(45) **Date of Patent: Jun. 14, 2016**

(54) AUTOMATED TECHNIQUES TO DEPLOY A CONVERGED INFRASTRUCTURE HAVING UNKNOWN INITIAL COMPONENT CONFIGURATIONS

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(73) Assignee: **Cisco Technology, Inc.**, San Jose, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 365 days.

(21) Appl. No.: **14/022,435**

(22) Filed: **Sep. 10, 2013**

(65) **Prior Publication Data**

US 2014/0109094 A1 Apr. 17, 2014

Related U.S. Application Data

(60) Provisional application No. 61/712,551, filed on Oct. 11, 2012.

(51) **Int. Cl.**
H04L 12/24 (2006.01)
G06F 9/46 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 41/0883*** (2013.01); ***G06F 9/46*** (2013.01); ***H04L 41/0806*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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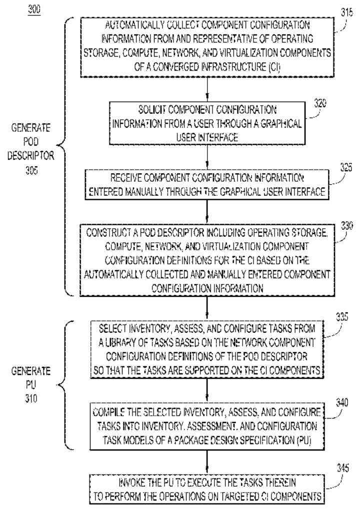
(74) *Attorney, Agent, or Firm* — Edell, Shapiro & Finnan, LLC

(57) ABSTRACT

A technique to adaptively configure components of a converged infrastructure (CI). Component configuration information is collected from and representative of operating storage, compute, and network components of the CI. A pod descriptor is constructed from the collected information. The pod descriptor includes operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information. A package specification unit is generated based on the component configuration definitions of the pod descriptor. The package specification unit includes tasks that, when executed, automatically inventory, assess, and configure targeted ones of the CI components. The technique executes the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

21 Claims, 14 Drawing Sheets


300
AUTOMATICALLY COLLECT COMPONENT CONFIGURATION INFORMATION FROM AND REPRESENTATIVE OF OPERATING STORAGE, COMPUTE, NETWORK, AND VIRTUALIZATION COMPONENTS OF A CONVERGED INFRASTRUCTURE (CI)
315
GENERATE POD DESCRIPTOR 305
SOLICIT COMPONENT CONFIGURATION INFORMATION FROM A USER THROUGH A GRAPHICAL USER INTERFACE
320
RECEIVE COMPONENT CONFIGURATION INFORMATION ENTERED MANUALLY THROUGH THE GRAPHICAL USER INTERFACE
325
CONSTRUCT A POD DESCRIPTOR INCLUDING OPERATING STORAGE, COMPUTE, NETWORK, AND VIRTUALIZATION COMPONENT CONFIGURATION DEFINITIONS FOR THE CI BASED ON THE AUTOMATICALLY COLLECTED AND MANUALLY ENTERED COMPONENT CONFIGURATION INFORMATION
330
GENERATE PU 310
SELECT INVENTORY, ASSESS, AND CONFIGURE TASKS FROM A LIBRARY OF TASKS BASED ON THE NETWORK COMPONENT CONFIGURATION DEFINITIONS OF THE POD DESCRIPTOR SO THAT THE TASKS ARE SUPPORTED ON THE CI COMPONENTS
335
COMPILE THE SELECTED INVENTORY, ASSESS, AND CONFIGURE TASKS INTO INVENTORY, ASSESSMENT, AND CONFIGURATION TASK MODELS OF A PACKAGE DESIGN SPECIFICATION (PU)
340
INVOKE THE PU TO EXECUTE THE TASKS THEREIN TO PERFORM THE OPERATIONS ON TARGETED CI COMPONENTS
345

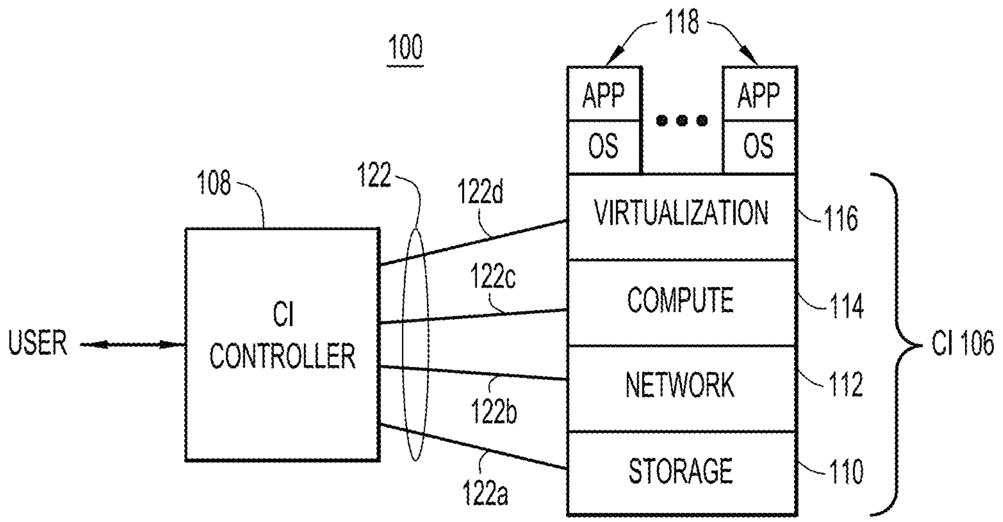

100
118
APP
OS
APP
OS
108
122
122d
VIRTUALIZATION
116
122c
COMPUTE
114
USER
CI CONTROLLER
NETWORK
112
CI 106
122b
STORAGE
110
122a

FIG.1

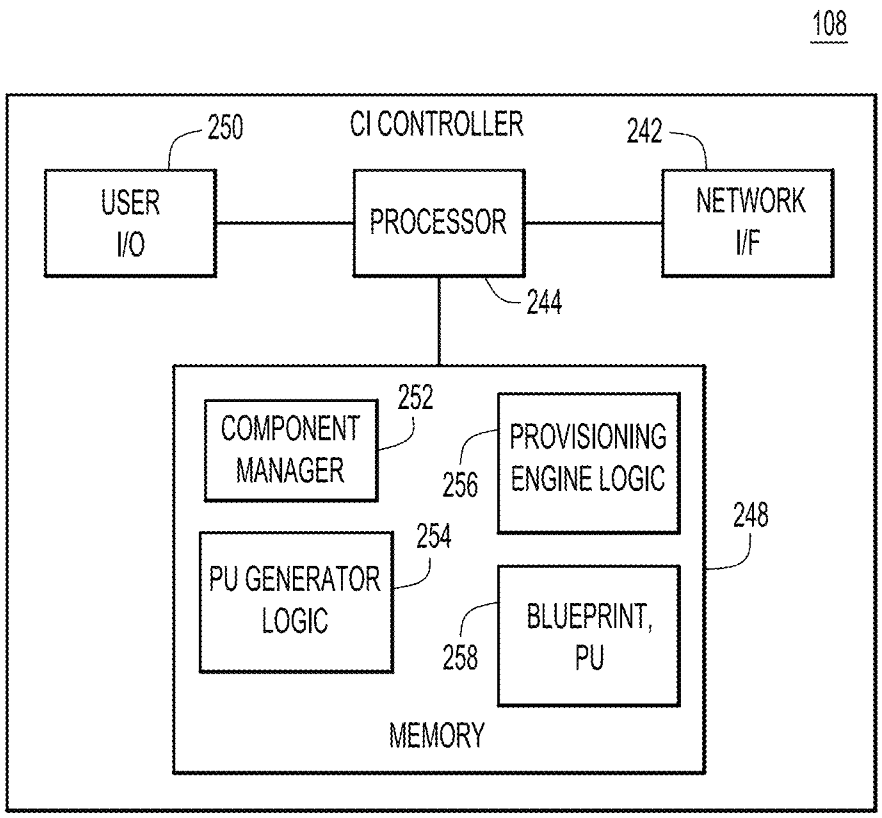
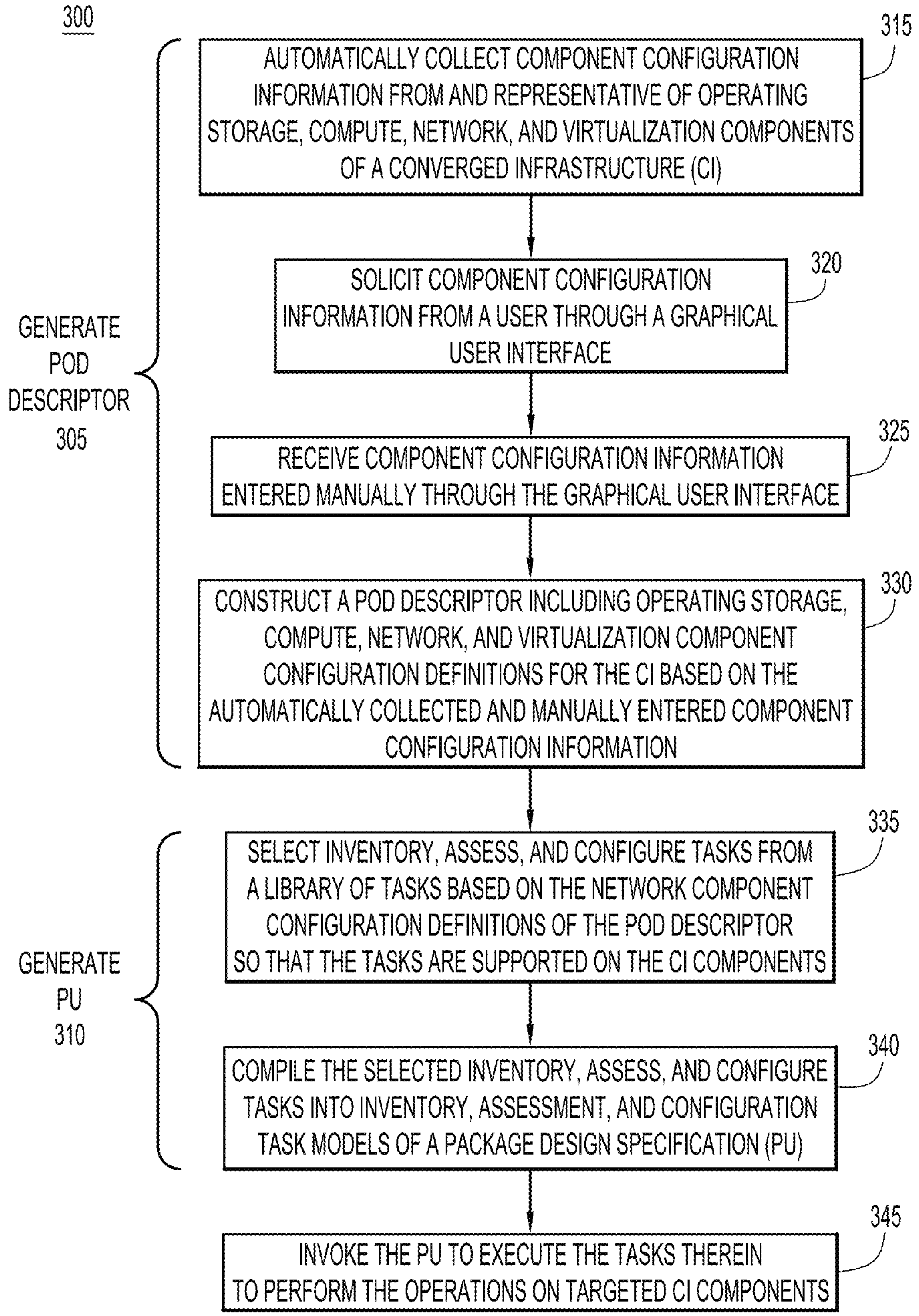

108
CI CONTROLLER
250
USER I/O
PROCESSOR
244
242
NETWORK I/F
COMPONENT MANAGER
252
PROVISIONING ENGINE LOGIC
256
248
PU GENERATOR LOGIC
254
BLUEPRINT, PU
258
MEMORY

FIG.2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325
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340
INVOKE THE PU TO EXECUTE THE TASKS THEREIN TO PERFORM THE OPERATIONS ON TARGETED CI COMPONENTS
345

FIG.3

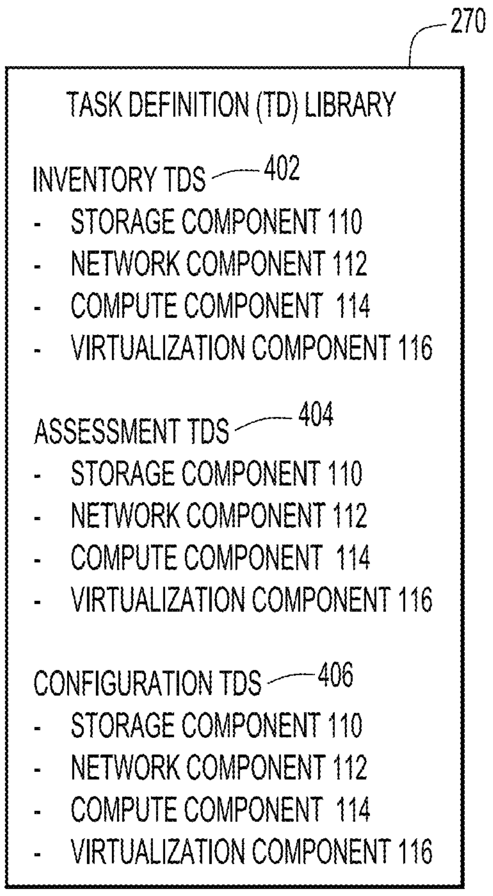

270
TASK DEFINITION (TD) LIBRARY
INVENTORY TDS
402
- STORAGE COMPONENT 110
- NETWORK COMPONENT 112
- COMPUTE COMPONENT 114
- VIRTUALIZATION COMPONENT 116
ASSESSMENT TDS
404
- STORAGE COMPONENT 110
- NETWORK COMPONENT 112
- COMPUTE COMPONENT 114
- VIRTUALIZATION COMPONENT 116
CONFIGURATION TDS
406
- STORAGE COMPONENT 110
- NETWORK COMPONENT 112
- COMPUTE COMPONENT 114
- VIRTUALIZATION COMPONENT 116

FIG.4

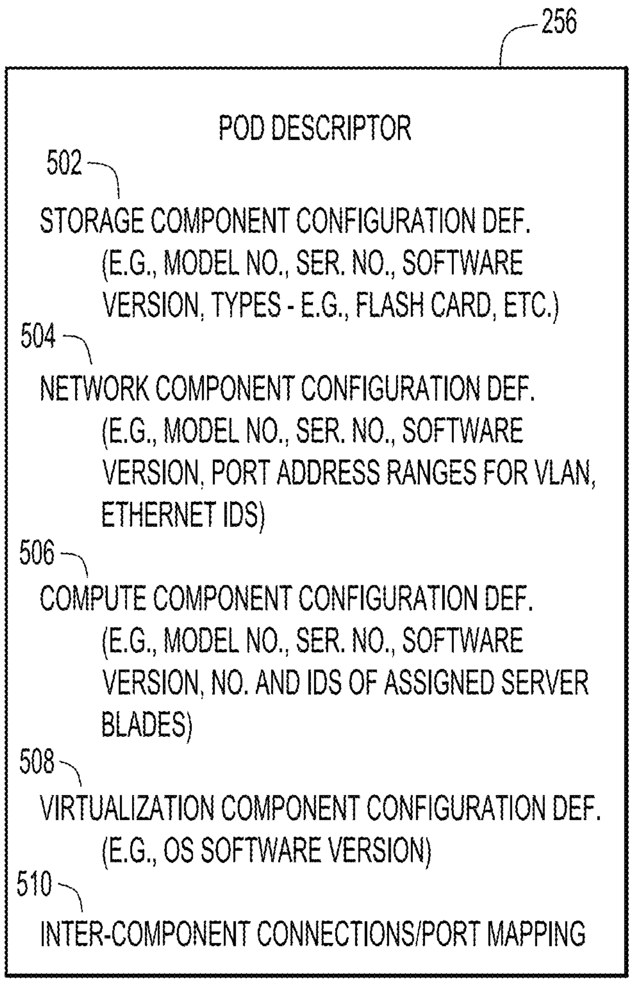

256
POD DESCRIPTOR
502
STORAGE COMPONENT CONFIGURATION DEF.
(E.G., MODEL NO., SER. NO., SOFTWARE VERSION, TYPES - E.G., FLASH CARD, ETC.)
504
NETWORK COMPONENT CONFIGURATION DEF.
(E.G., MODEL NO., SER. NO., SOFTWARE VERSION, PORT ADDRESS RANGES FOR VLAN, ETHERNET IDS)
506
COMPUTE COMPONENT CONFIGURATION DEF.
(E.G., MODEL NO., SER. NO., SOFTWARE VERSION, NO. AND IDS OF ASSIGNED SERVER BLADES)
508
VIRTUALIZATION COMPONENT CONFIGURATION DEF.
(E.G., OS SOFTWARE VERSION)
510
INTER-COMPONENT CONNECTIONS/PORT MAPPING

FIG.5

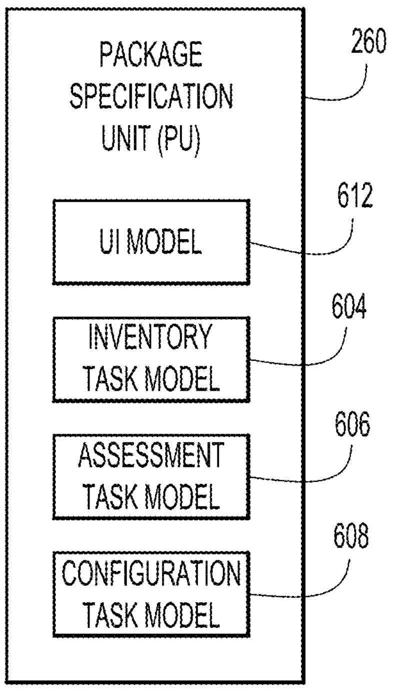
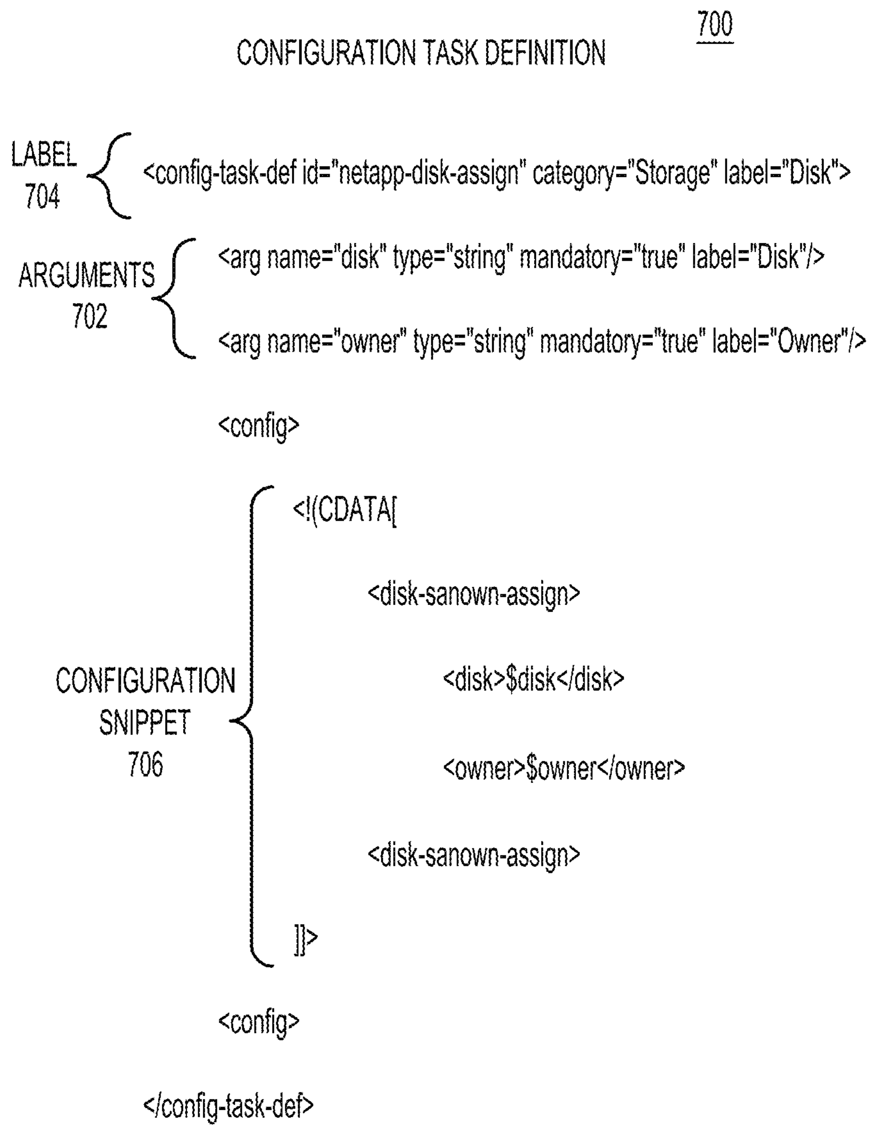

PACKAGE SPECIFICATION UNIT (PU)
260
UI MODEL
612
INVENTORY TASK MODEL
604
ASSESSMENT TASK MODEL
606
CONFIGURATION TASK MODEL
608

FIG.6



```
<config-task-def id="netapp-disk-assign" category="Storage" label="Disk">
    <arg name="disk" type="string" mandatory="true" label="Disk"/>
    <arg name="owner" type="string" mandatory="true" label="Owner"/>
    <config>
        <!(CDATA[
            <disk-sanown-assign>
                <disk>$disk</disk>
                <owner>$owner</owner>
            <disk-sanown-assign>
        ]]>
    <config>
</config-task-def>
```

FIG.7

INVENTORY TASK DEFINITION 800

```
                                          802
<task id="n5k-B-system-info" ref="query-network-device" label="System Info" >
        <task-arg name="variable" value="DeviceInfo,NX-OS" />
804     <task-arg name="parentElem" value="DeviceInfo" />
        <task-arg name="attrLst"
805 value="Hostname,Model, Version,SerialNumber" />
        <returns name="Hostname,Model,Version,SerialNumber" type="table" />
</task>                                 806
```

FIG.8A

INVENTORY TASK DEFINITION 810

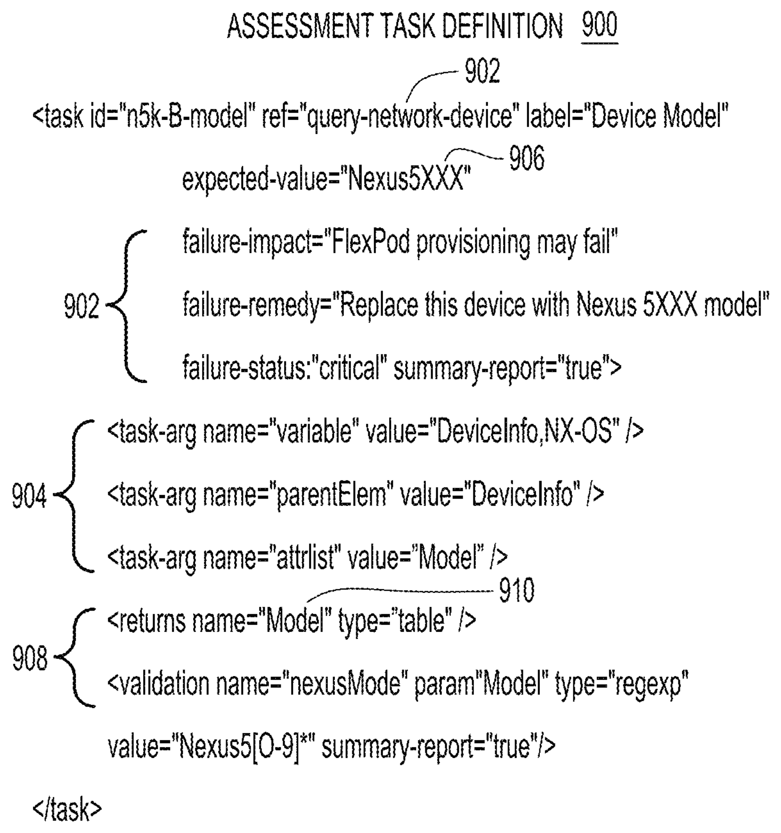
```
                                          812
<task ref="query-netapp" id="fcp-adapter-list-info" />
         <task-arg value="fcp-adapter-list-info" name="varList" />
814      <task-arg value="fcp-config-adapter-info" name="parentElem" />
         <task-arg value="adapter,port-name" name="attrList" />
816      <returns type="table" name="adapter,port-name" />
         </task>                              818
```

FIG.8B

INVENTORY TASK DEFINITION 820

```
                                          832
<task ref="query-netapp" id="emc-get-disk-info" >
         <task-arg value="fcp-adapter-list-info" name="varList" />
834      <task-arg value="fcp-config-adapter-info" name="parentElem" />
         <task-arg value="adapter,port-name" name="attrList" />
836      <returns type="table" name="adapter,port-name" />
         </task>                              838
```

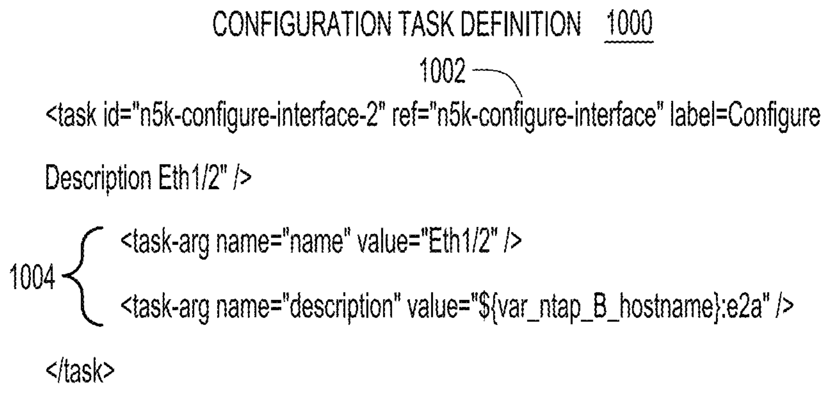
FIG.8C



```
ASSESSMENT TASK DEFINITION 900

<task id="n5k-B-model" ref="query-network-device" label="Device Model"
        expected-value="Nexus5XXX"
        failure-impact="FlexPod provisioning may fail"
        failure-remedy="Replace this device with Nexus 5XXX model"
        failure-status:"critical" summary-report="true">
    <task-arg name="variable" value="DeviceInfo,NX-OS" />
    <task-arg name="parentElem" value="DeviceInfo" />
    <task-arg name="attrlist" value="Model" />
    <returns name="Model" type="table" />
    <validation name="nexusMode" param"Model" type="regexp"
    value="Nexus5[O-9]*" summary-report="true"/>
</task>
```

FIG.9



```
CONFIGURATION TASK DEFINITION 1000

<task id="n5k-configure-interface-2" ref="n5k-configure-interface" label=Configure
Description Eth1/2" />
    <task-arg name="name" value="Eth1/2" />
    <task-arg name="description" value="${var_ntap_B_hostname}:e2a" />
</task>
```

FIG.10

TASK SEQUENCE 1100

```
        <task id="create-volume-1"
1102
     \_ ref="netapp-create-volume"

        label="Create volume for Infrastructure vFiler">

        </task>

           { <task-arg name="name" value="${volume_name}" />
      1104 {  <task-arg name="aggr" value="${aggregate_name}" />
           { <task-arg name="size" value="${volume_size_in_mb}m />

        </task>

                                    1106
        <task id="create-volume-2" ref="netapp-create-volume" label="Create volume for NFS Datastore">

           { <task-arg name="name" value="${volume_ds_name}" />
      1108 { <task-arg name="aggr" value="${aggregate_name}" />
           { <task-arg name="size" value="${ds_volume_size_in_mb}m" />

        </task>

                                 1120
        <task id="enable-sis-l" ref="netapp-enable-sis" label="Enable sis" >

     1122 --- <task-arg name="path" value="${path_name}" />

        </task>
```

FIG.11

FIG.12A

INVENTORY TASK MODEL
- SERIAL NUMBER
- PORT LIST AND STATUS
- NEIGHBOR STATUS

$\}$ 1200A

FIG.12B

ASSESSMENT TASK MODEL
- SOFTWARE VERSION
- DEVICE MODEL
- LICENSE

$\}$ 1200B

FIG.12C

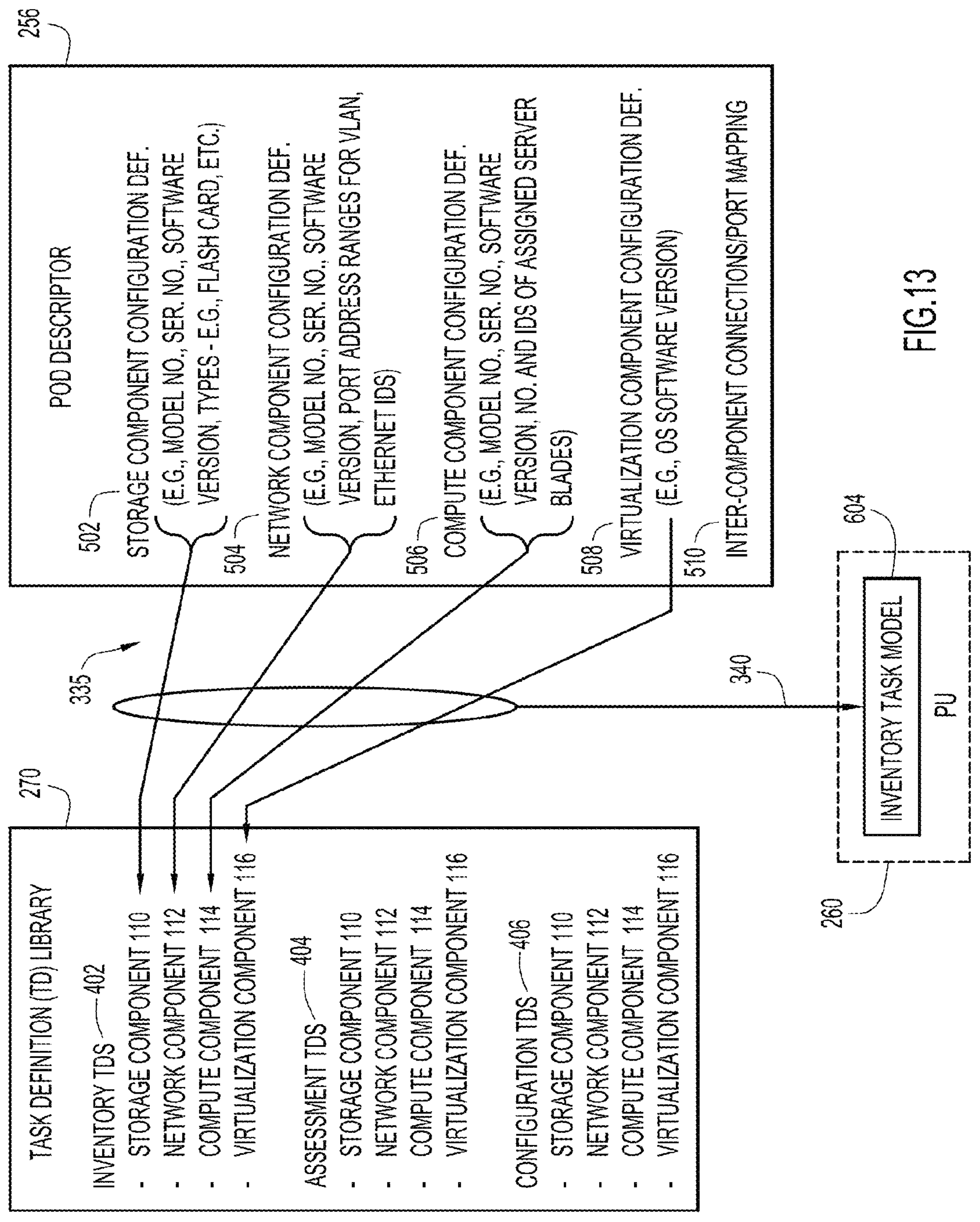
CONFIGURATION MODEL
- AGGREGATE CREATION
- VOLUME CREATION
- VOLUME EXPORT

$\}$ 1200C

FIG.12D

INPUT MODEL
- DISK SIZE
- WWPN START ADDRESS
- WWPN SIZE
- MAC POOL START ADDRESS
- MAC POOL SIZE

$\}$ 1200D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(E.G., MODEL NO., SER. NO., SOFTWARE VERSION, NO. AND IDS OF ASSIGNED SERVER BLADES)
508
VIRTUALIZATION COMPONENT CONFIGURATION DEF.
(E.G., OS SOFTWARE VERSION)
510
INTER-COMPONENT CONNECTIONS/PORT MAPPING
335
340
604
INVENTORY TASK MODEL
PU
260
270
TASK DEFINITION (TD) LIBRARY
INVENTORY TDS 402
- STORAGE COMPONENT 110
- NETWORK COMPONENT 112
- COMPUTE COMPONENT 114
- VIRTUALIZATION COMPONENT 116
ASSESSMENT TDS 404
- STORAGE COMPONENT 110
- NETWORK COMPONENT 112
- COMPUTE COMPONENT 114
- VIRTUALIZATION COMPONENT 116
CONFIGURATION TDS 406
- STORAGE COMPONENT 110
- NETWORK COMPONENT 112
- COMPUTE COMPONENT 114
- VIRTUALIZATION COMPONENT 116

FIG.13

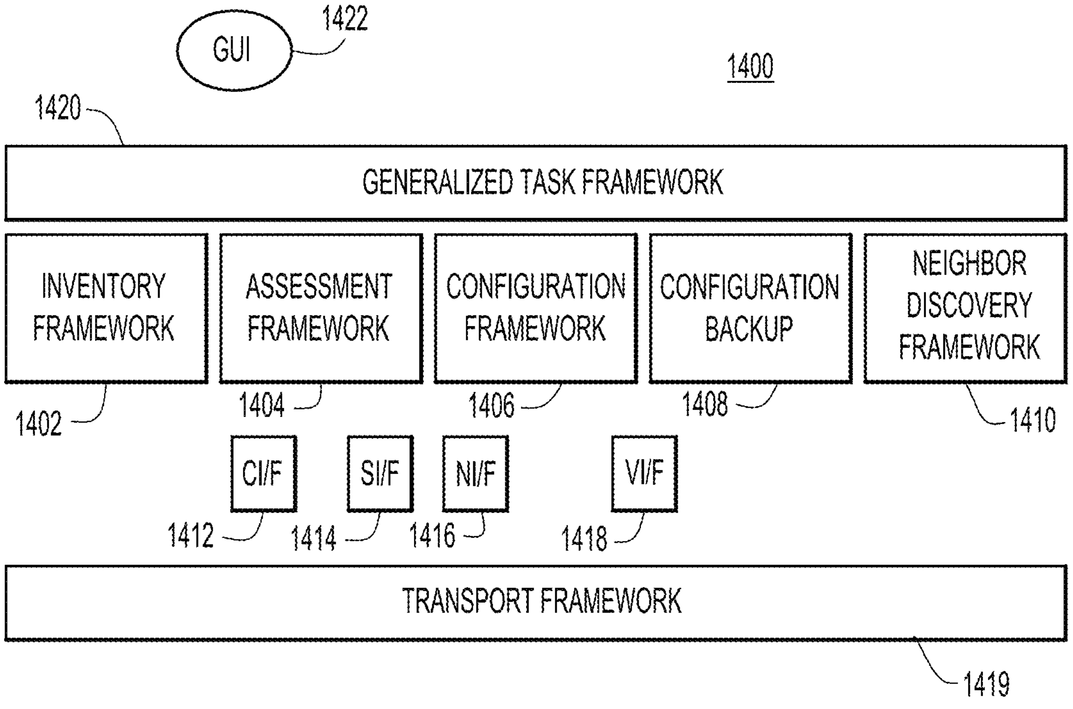
GUI
1422
1400
1420
GENERALIZED TASK FRAMEWORK
INVENTORY FRAMEWORK
ASSESSMENT FRAMEWORK
CONFIGURATION FRAMEWORK
CONFIGURATION BACKUP
NEIGHBOR DISCOVERY FRAMEWORK
1402
1404
1406
1408
1410
CI/F
SI/F
NI/F
VI/F
1412
1414
1416
1418
TRANSPORT FRAMEWORK
1419

FIG.14

1500

- FlexPod for VMware Deployment Model
- FlexPod for VMware Overview
- FlexPod for VMware Architecture
- FlexPod for VMware Configuration Deployment
  - Cabling Information
  - 1510 NetApp FAS3210A Deployment Procedure--Part I
  - 1512 Cisco Nexus 5548 Deployment Procedure--Part I
  - Cisco Unified Computing System Deployment Procedure
  - Gather Necessary Information
  - 1516 VMware ESXi Deployment Procedure
  - VMware vCenter Server Deployment Procedure
  - Cisco Nexus 1010 and 1000V Deployment Procedure
  - NetApp Virtual Storage Console Deployment Procedure
  - 1510 NetApp Operations Manager Deployment Procedure
- Appendix--FlexPod for VMware Configuration Information
  - Global, NetApp, Cisco, VMware Configuration Information
  - 1510 NetApp FAS3200 Sample Configuration
    - Filer Sample Interface Configuration
    - Sample Startup Information Configuration
    - Sample Volume Information
  - 1512 Cisco Nexus 5548, 1010, 1000v Sample Running Configurations
  - Cisco Unified Computing System Configuration Extracts
    - Sample Chassis Discovery Policy Configuration
    - Create an Organization
    - 1512 Create MAC Address Pools
    - Create Global VLAN Pools
    - Create a Network Control Policy
    - Create vNIC Template
    - Define QoS Policies and Jumbo Frames
    - Create Uplink Port-Channels to the Cisco Nexus 5548 Switches
    - 1512 Create WWNN Pool
    - Create WWPN Pools
    - Create Global VSANs
    - Create vHBA Templates
    - Create Boot Policies
    - 1514 Create Server Pools
    - Create Service Profile Templates
    - Add a Block of IP Addresses for KVM Access

FIG.15

AUTOMATED TECHNIQUES TO DEPLOY A CONVERGED INFRASTRUCTURE HAVING UNKNOWN INITIAL COMPONENT CONFIGURATIONS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 61/712,551, filed Oct. 11, 2012, which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present disclosure relates to automated configuring of converged infrastructures.

BACKGROUND

A data center, cloud resource, or the like, may be implemented in the form of a converged infrastructure (CI). The CI is a set of integrated Information Technology (IT) components, such as storage, network, compute, and virtualization software and/or device components. Vendors of the various CI components typically provide validated design blueprints in the form of human readable specifications that define to a user extensive step-by-step manual procedures required to perform critical operations on the components. Such operations include provisioning (i.e., initially configuring or setting-up), reconfiguring/modifying, inventorying, and assessing/validating the CI components. Therefore, the user is required to step through painstaking manual procedures set forth in the blueprints to perform the critical operations. This is time consuming and burdensome for the user.

A given design blueprint generally assumes specific, fixed hardware and/or software configurations of each of the storage, network, compute, and virtualization components of the CI. The assumed CI configurations support the critical operations defined in the blueprint. In practice, however, the CI components often have unknown operational configurations that vary or deviate from the assumed configurations. The configuration differences complicate interactions between the user, the blueprint, and the actual CI components because the user is forced to detect the differences manually and then make corresponding adjustments in order to follow the blueprint. This adds complexity and cost to performing the critical operations on the CI components.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an example converged infrastructure environment in which a converged infrastructure (CI) is configured by and operates under control of a CI controller.

FIG. **2** is a block diagram of an example CI controller configured to perform management operations related to the CI from FIG. **1**.

FIG. **3** is an example sequence of operations to generate a pod descriptor (PD) from collected component configuration information, and to generate a package specification unit or package unit (PU) based on the PD that may be used to perform operations on the CI of FIG. **1**.

FIGS. **4**, **5**, and **6** are example block diagrams of a Task Definition Library, a PD, and a PU, respectively, referenced by the operations in FIG. **3**.

FIGS. **7**, **8**A-**8**C, and **9**-**11** depict example task definitions and associated tasks embedded therein.

FIGS. **12**A-**12**D depict example PU model menus that may be displayed when the PU is invoked in in the operations of FIG. **3**.

FIG. **13** is an illustration of relationships/interactions between operations from FIG. **3** to generate a portion of a PU, a Task Definition Library, and a PD.

FIG. **14** is a block diagram of an example provisioning engine to support PU activation and use under user control.

FIG. **15** is an excerpt from an example human readable CI design blueprint for FlexPod™ from which task definition for a Task Definition Library may be generated.

DESCRIPTION OF EXAMPLE EMBODIMENTS

Overview

Techniques are presented herein to automate and simplify for a user a deployment of a converged infrastructure (CI), which may have an initially unknown hardware and/or software configuration. One technique automatically collects component configuration information from and representative of operating storage, compute, and network components of the CI. Then, a pod descriptor is constructed based on the collected information. The pod descriptor includes operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information. A package specification unit is generated based on the component configuration definitions of the pod descriptor. The package specification unit includes tasks that, when executed, automatically inventory, assess, and configure targeted ones of the CI components. The technique executes the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

Example Embodiments

A converged infrastructure (CI) is a modular, integrated, often pre-configured or at least easily configured, set of information technology (IT) components, typically including storage, network, compute, and virtualization components, that may be shared across multiple user applications that require storage, network, and compute resources. Due to the modular nature of the CI, the CI components made available to the user applications may be scaled up and down relatively easily and efficiently in order to accommodate corresponding increases and decreases in user application resource requirements. Examples of known converged infrastructures (CIs) include, but are not limited to, FlexPod™ by NetApp and Cisco, VSPEX by EMC, and Vblock™ by VCE. Such known CIs are configured and operated in accordance with respective vendor CI specifications referred to herein as “blueprints” that have become quasi-industry standards.

CI Environment

Referring first to FIG. **1**, a block diagram of an example (CI) environment **100** is shown in which a CI **106** is configured by and operates under control of, a CI Controller **108**. CI **106** includes an integrated set of components, including a storage component **110** to provide data storage, a network component **112** to provide connectivity to external devices and communication networks, a compute or server component **114** to provide processing capacity to the CI, and a virtualization component **116**, such as a hypervisor, to host virtual environments. Virtualization component **116** may host multiple virtual user operating environments **118** on the stack of CI components **110**, **112**, and **114**. Virtual user operating environments **118** may each include a virtualized operating system (OS), and one or more applications (APs) executing in the virtualized OS. Components **110**, **112**, and **114** provide respective data storage, network, and compute resources required by each OS and the respective one or more APs.

At a high-level, CI Controller **108** serves as a unified, automated, resource configured to manage CI **106**. CI Controller **108** includes one or more Graphical User Interfaces (GUIs) through which a user may issue commands and provide data to the CI Controller to selectively cause the controller to perform operations with respect to CI **106**, such as to provision, configure, assess/validate, and monitor the CI. As used herein, the "provision" operation may be considered an initial configure operation to configure the components of the CI for useful operation after the components have been unpacked and powered ON for the first time. Therefore, the terms "provision" and "configure" and their various forms are used interchangeably herein. Exemplary provision operations may establish storage volumes or partitions on storage component **110**, establish virtual local area network (vlan) pools on network component **112**, assign computing blades on compute component **114**, and establish virtual resource pools on virtualization component **116**.

CI Controller **108** manages CI **106** over a bi-directional communication interface **122**, including component interfaces **122***a*, **122***b*, **122***c*, and **122***d* each to communicate directly with a respective one of storage, network, compute, and virtualization components **110**, **112**, **114**, and **116**. Component interfaces **122***a*-**122***d* may support communications in accordance with any number of different protocols, including, for example, a network protocol such as the HyperText Transfer Protocol (HTTP). To the extent that components **110**-**116** of CI **106** support different interface protocols, such as a Rich Text or Extensible Markup Language (XML), component interfaces **122***a*-**122***d* of CI Controller **108** correspondingly support the different protocols, and the CI Controller may be configured to communicate with components **110**-**116** using different protocols to maintain interface compatibility with the components as necessary.

As mentioned above, a specific design of CI **106** may be in accordance with a vendor blueprint. Because the blueprint complies with vendor specifications, the blueprint is said to represent or define a "validated" design of a CI. In one form, the blueprint is a human readable text- and graphics-based document that defines to a user manual step-by-step procedures and related information required to deploy, i.e., inventory, assess/validate, provision, and configure/reconfigure, each of the CI components in accordance with the specific design. An excerpt from an example blueprint for FlexPod™ is depicted in, and will be described briefly later in connection with, FIG. **15**. The user may follow the manual procedures outlined in the blueprint to deploy CI **106**; however, this is a manually intensive and time consuming activity. The design blueprint generally assumes specific, fixed hardware and/or software configurations for the storage, network, compute, and virtualization components of the CI. The assumed CI configurations support the component operations defined in the blueprint. In practice, however, the CI components may have operational hardware and/or software configurations that vary or deviate from the assumed configurations.

The techniques presented herein advantageously automate and simplify for the user the deployment of CI **106**, which may have an initially unknown hardware and/or software configuration. The actual configuration may differ from a given blueprint. Thus, the techniques presented herein may be referred to as techniques to automatically deploy a CI having unknown initial hardware and/or software component configurations. In brief, in an initial phase, CI Controller **108** automatically determines the hardware and/or software configuration of CI **106**. To do this, CI controller **108** collects component hardware and/or software configuration information from the CI components while the components are operating and constructs a pod descriptor (PD) that defines the actual CI component configurations based on the collected information. Then, CI controller **108** automatically generates a package specification unit (PU) from the PD and a library of tasks to which the CI controller has access. The PU includes interactive menus and tasks selected from the task library that control/interact directly with the CI components of CI **106**. The tasks are "machine readable" instructions or commands formatted to conform to corresponding ones of CI component interface specifications so as to be understood by a CI component targeted by the command. The tasks, when executed, perform operations on targeted components of the CI. Because the PD accurately reflects the actual operating hardware and/or software configuration of the CI components, and because the PU is generated based on the PD, the PU also accurately reflects the actual CI components in that the tasks included in the PU are known to be supported by the CI components.

In a subsequent operational phase, the user invokes/activates the PU on CI Controller **108**. The tasks embedded in the PU or to which the PU has access interact directly with targeted ones of the CI components of CI **106** to configure and operate the CI components in an automated manner. The activated PU also includes and invokes an interactive user interface through which the user may control the PU to inventory, assess/validate, provision, and configure/reconfigure the CI components in a user controlled, automated manner. In other words, the PU executes the necessary component tasks embedded therein to automatically perform user requested operations on CI **106**.

CI Controller

Reference is now made to FIG. **2**, which shows an example block diagram of CI Controller **108** configured to perform the operations described herein, and particularly, to generate the PD and the PU and then activate the PU to interact with CI **106**. There are numerous possible configurations for CI Controller **108** and FIG. **2** is meant to be an example. CI Controller **108** includes a network interface unit **242**, a processor **244**, memory **248**, and a user Input/Output module **250** used in association with the one or more GUIs to enable the user to interface with the CI Controller. The network interface (I/F) unit **242** is, for example, an Ethernet card device that allows the CI Controller **108** to communicate over a network, e.g., a wired (Ethernet) network. Network I/F **242** may also include wireless connection capability. Interface **122** (from FIG. **1**) may be implemented through network I/F unit **242**. The processor **244** is a microcontroller or microprocessor, for example, configured to execute software instructions stored in the memory **248**.

The memory **248** may comprise read only memory (ROM), random access memory (RAM), magnetic disk storage media devices, optical storage media devices, flash memory devices, electrical, optical, or other physical/tangible (e.g., non-transitory) memory storage devices. Thus, in general, the memory **248** may comprise one or more computer readable storage media (e.g., a memory device) encoded with software comprising computer executable instructions and when the software is executed (by the processor **244**) it is operable to perform the operations described herein. For example, the memory **248** stores or is encoded with instructions for Component Manager Logic **252** to perform generalized management operations on CI **106**, PD Generator Logic **254** to generate a PD **256** based on collected CI component configuration information, PU Generator Logic **258** to generate a PU **260** based on the PD, and Provisioning Engine

(PE) Logic **262** to activate the PU and cooperate with the PU to perform the inventory, assess/validate, provision, and configure/reconfigure operations mentioned above. In addition, memory **248** stores PD **256**, PU **260**, and task definitions with associated tasks in a task definition library **270**. The memory GUI logic may be divided among logic units **252**, **258**, and **262** as necessary to support the respective logic operations.

Operation Flowchart

With reference to FIG. **3**, a sequence of operations **300** includes a high-level operation **305** to generate PD **256** and a high-level operation **310** to generate PU **260** based on the PD.

High-level operation **305** includes detailed operations **315-330**, now described.

At **315**, PD Generator logic **254** automatically collects or inventories component configuration information from and representative of operating storage, compute, network, and virtualization components **110-116** of CI **106**. Logic **254** may execute inventory tasks to collect the component configuration information for each of CI components **110-116** over interfaces **112***a*-**122***d*. Examples of such inventory tasks will be described below in connection with FIGS. **8**A-**8**C. Example component configuration information collected from each of CI components **110-116** includes, but is not limited to, a serial number, a model number, a software and/or operating system version, numbers and types of external interfaces (e.g., universal serial bus (USB) connectors, fibre channel protocol adapters (FCBs), etc.), numbers and identities of server blades for compute component **114**, numbers and types of supported memory for storage component **110** (e.g., flash memory cards), numbers and addresses of virtual local area networks (vlans) for network component **112**, inter-component connections and port mappings, and so on.

At **320**, logic **254** prompts a user for customizable component configuration information through a graphical user interface.

At **325**, logic **254** receives customized component configuration information entered by the user manually through the graphical user interface. Operations **320** and **325** are optional.

At **330**, logic **254** constructs PD **256** including storage, compute, network, and virtualization component configuration definitions based on the automatically collected and manually entered component configuration information. The storage, compute, network, and virtualization component configuration definitions represent operating hardware and/or software configuration profiles of corresponding ones of storage, compute, network, and virtualization components **110-116**.

High-level operation **310** receives PD **256** as an input and generates PU **260** based on the PD and tasks selected from task definition library **270**. High-level operation **310** includes detailed operations **335** and **340**, now described.

At **335**, PU Generator logic **258** selects inventory, assess, and configure tasks from task definition library **270** based on the network component configuration definitions of PD **256** so that the selected tasks are supported on the CI components (as operationally configured).

At **340**, logic **258** compiles the selected inventory, assess, and configure tasks into corresponding ones of inventory, assessment, and configuration task models of PU **260**. Logic **258** also generates a user interface (UI) model of PU **260** that is capable of displaying operational menus to the user.

At **345**, PU **260** is invoked to execute the tasks in the task models of PU **260** to perform operations on targeted ones of operating CI components **110-116**, e.g., to inventory, assess, and configure targeted components.

Data Structures for Task Definition Library, Pod Descriptor, and Package Design Unit

As described above in connection with FIG. **3**, operations **300** rely on and generate various data structures, including task definition library **270**, PD **256**, and PU **260**, each of which is now described in connection with FIGS. **4**, **5**, and **6**, respectively.

Turning to FIG. **4**, an example block diagram of task definition library **270** is shown. Task definition library **270** includes many task definitions. Each of the many task definitions is associated with a specific task that, when executed, performs an operation on a targeted one of CI components **110-116**. The task is executed when the associated task definition is invoked or called by name, as will be described more fully below in connection with FIGS. **7-11**.

Task definition library **270** includes:

i. multiple inventory task definitions **402** associated with inventory tasks to read data from targeted ones of the CI components, e.g., read model number, software version, port mappings, etc.;
ii. multiple assessment task definitions **404** associated with assessment tasks to assess/validate information, e.g., model number, software version, etc., related to targeted ones of the CI components; and
iii. multiple configuration task definitions **406** associated with configuration tasks to configure targeted ones of the CI components, e.g., establish vlan pools, assign server blades, etc.

Because each task definition is associated with a specific task, task definition library **270** is also referred to herein as a task library to store tasks. Also, selecting a task definition results in selecting the associated task.

Turning to FIG. **5**, an example block diagram of PD **256** is shown. PD **256** includes:

i. a storage component configuration definition **502** representative of an operating hardware and/or software configuration of storage component **110**;
ii. a network component configuration definition **504** representative of an operating hardware and/or software configuration of network component **112**;
iii. a compute component configuration definition **506** representative of an operating hardware and/or software configuration of storage component **114**;
iv. a virtualization component configuration definition **508** representative of an hardware and/or software operating configuration of virtualization component **110**; and
v. an inter-component connections/port-mapping definition **510** that defines inter-component connections and port mapping in CI **106**.

Each of component configuration definitions **502-508** lists respective CI component features collected in operation **315** of FIG. **3** (e.g., model number, software version, etc., as depicted in FIG. **5**).

With reference to FIG. **6**, there is shown an example block diagram of PU **260**. PU **600** includes:

i. an Inventory Task Model **604** that is associated with inventory tasks to solicit and read component information from CI components **110-116**;
ii. an Assessment Task Model **606** that includes or is associated with assessment tasks to assess/validate the CI components;
iii. a Configuration Task Model **608** that includes or is associated with configure tasks to configure the CI components; and
iv. a User Interface (UI) Model **612** that includes logic to generate display prompts or menus to solicit and receive CI component information from the user, and provide

the received information to the other PU models as appropriate. Display menus associated with each of the Task Models **604-608** (discussed below in connection with FIGS. **12**A-**12**D) may be included in the corresponding Task Models or in UI Model **612**.

The PU models may be generated in formats including, but not limited to, Extensible Markup Language (XML), JavaScript Object Notation (JSON), and so on.

Task Definitions

As described above, task definitions and their associated tasks represent fundamental building blocks of task definition library **270** and PU **260**. Therefore, numerous examples of task definitions and associated tasks are discussed below in connection with FIGS. **7-11**. Specifically, FIGS. **7-11** depict example task definitions **700**, **800**, **810**, **820**, **900**, and **1000** that may be selected from task definition library **270** at operation **335** of FIG. **3** and compiled into Inventory, Assessment, and/or Configuration Task Models **604-608** of PU **260** at operation **340**, as appropriate. Each of PU Task Models **604-608** typically includes many such task definitions and associated tasks.

Generally, each task definition includes (i) a human readable task identifier (ID) that may be displayed in and selected from a corresponding task model menu, (ii) one or more CI component readable commands (also referred to interchangeable as "task" or "tasks" above) associated with the task ID and each to perform a corresponding operation on a targeted component when the task is executed (i.e., when the task definition is called by its task ID), and (iii) one or more task arguments through which one or more component parameters are passed to the tasks/commands and to the targeted component when the task definition is called by its task ID to execute the embedded task. The necessary component parameters associated with a given task (of the task definition) may be solicited from the user before the task definition is called through a corresponding UI model menu (e.g., UI menu **500**D in FIG. **5**D), or when the task definition is called by name to executed its embedded task. The task definitions (task ID, tasks/commands/, and task arguments) may be generated in any number of different formats including, but not limited to, plain text, XML, JSON, and so on.

The tasks/commands in each task definition conform to a vendor command specification for the targeted CI component. For example, the syntax and structure of each command may follow a vendor defined data model for the targeted component. Because each command is formatted according to the corresponding vendor defined data model, each task/command is capable of being interpreted or understood by the targeted component. In contrast, the corresponding task ID is a functional, vendor-independent (i.e., abstracted), alpha-numeric ID that is easily understood by the user. Thus, the task ID is abstracted from the vendor command specification to a higher level that is understandable to a person.

Turning now to FIG. **7**, there is depicted task definition **700** to perform a configure operation on storage component **110** of CI **106**, namely to make an owner assignment to a disk. Other task definitions may be constructed with a similar overall framework, i.e., structure and syntax, as task definition **700** in order to perform additional configure operations on storage component **110**, or to perform configure operations on the compute, network, and virtualization components of CI **106**.

Task definition **700** includes a high-level label section **702**, an argument section **704**, and a configuration snippet **706** (also referred to as a "configuration object fragment"). Label section **702** includes an easy to understand, functional, identifier (ID) that identifies task definition **700**. In the example of FIG. **7**, label section **702** includes an alphanumeric task ID "netapp-disk-assign" to identify the task definition functionally, a component category "Storage" to identify the CI component (namely, storage) to be configured functionally, and a label "Disk." Other possible component categories corresponding to the other CI components include "Compute," "Network," and "Virtualization" categories.

Argument section **704** includes definitions, i.e., names and corresponding type descriptors, of one or more component parameters to be received by configuration task **700** when it is invoked. The received component parameters are passed to configuration snippet **706**. In the example of FIG. **7**, argument section **704** defines two arguments corresponding to two configuration parameters to be received and passed to configuration snippet **706**. The two arguments include (i) "disk" of type "string," and (ii) "owner" also of type "string."

Configuration snippet **706** includes a configuration command or task "disk-sanown-assign." The configuration command "disk-sanown-assign" performs a configure operation, namely, disk ownership assignment, on target storage component **110**, when task definition **700** is invoked. When task definition **700** is invoked, the following operations occur. First, configuration parameters "$Disk" and "$Owner" are received through argument section **704** and passed to the configuration command "disk-sanown-assign" of configuration snippet **706**. Then, the configuration command "disk-sanown-assign" along with the passed parameters "$Disk" and "$Owner" are pushed, i.e., provided, to target storage component **110** to perform the disk assignment operation on the storage component. The operations just described with respect to task definition **700** are understood to extend generally to other task definitions that may be constructed and invoked in accordance with the techniques described herein to perform operations on all of the components **110-116** of CI **106**.

Turning to FIG. **8**A, inventory task definition **800** includes a task identifier **802** "query-network-device," accepts three component parameters **804** (also referred to herein as arguments **804**, and includes a task/command **805** that returns inventory information **806** (e.g., Hostname, Model, Version, SerialNumber) queried from the targeted CI component when the task/command is executed.

Turning to FIG. **8**B, inventory task definition **810** includes a task identifier **812** "fcp-adapter-list-info," accepts three component parameters **814**, and a task/command **816** to return inventory information **818** (e.g., adapter, port-name) queried from targeted network component **112**.

Turning to FIG. **8**C, inventory task definition **830** includes a task identifier **832** "emc-get-disk-info," accepts three component parameters **834**, and a task/command **836** to return inventory information **838** (e.g., adapter, port name) queried from targeted storage component **110**.

Turning to FIG. **9**, assessment/validation task definition **900**, identified at **902** as "query-network-device," validates a "Device Model" of network component **112**. Task definition **900** accepts three arguments **904** and an expected value **906** for the Device Model. Task definition **900** includes a task/command **908** that queries network component **112** for its model, which is returned at **910** as "Model." Task definition **900** compares the returned model **910** against the expected value **906**. If the compare indicates a mismatch, i.e., the compare failed, then the task reports/displays this failure status according to result descriptors **920**. Alternatively, if there is no mismatch, i.e., the compare passes, then the task reports/displays the pass status.

Turning to FIG. **10**, another configuration task definition **1000** identified at **1002** accepts two arguments **1004** and configures an Ethernet port of network component **112**.

FIGS. **7-10** discussed above depict separate task definitions each associated with a task to perform a discrete operation on a targeted one of CI components **110-116**. Task Models **604-608** of PU **260** may each include many task definitions and associated tasks, and may also include scripts to invoke/execute tasks in a defined sequence or order to perform a specific operational goal on targeted CI components, as is now discussed in connection with FIG. **11**. In FIG. **11**, there is depicted an example script **1100** of task IDs of task definitions to achieve specific configure operations on storage component **110** of CI **106**, namely to create a volume **1** and a volume **2** on storage component **110**. Script **1100** may be generated and compiled at operations **335** and **340** in FIG. **3**.

Script **1100** references a first call **1102** to a task definition identified as "netapp-create-volume" to create a volume **1** on storage component **110**. A call by identifier to a task definition results in execution of the embedded task. The call receives a first set of parameters **1104** "${volume_name}," "${aggregate_name}," and "{volume_size_in_mb}." When invoked at call **1102**, the task identified as "netapp-create-volume" will create volume **1** on storage component **110** based on the parameters **1104**.

Script **1100** references a subsequent, second call **1106** to the task definition identified as "netapp-create-volume" to create a volume **2** on storage component **110**. The call receives a second set of parameters **1108** "${volume_ds_name}," "${aggregate_name}," and "{volume_size_in_mb}." When invoked the second time at call **1106**, the task identified as "netapp-create-volume" will create volume **2** on storage component **110** based on the parameters **1108**. In this way, the task definition identified as "netapp-create-volume" may be reused in succession with different parameters to configure different aspects of storage component **110**.

Script **1100** includes a subsequent call **1120** to a task definition identified as "netapp-enable-sis," which accepts a single parameter **1122** to further configure storage component **110**.

Scripts may be generated to configure all of the components **110-116** of CI **106**. For example, assume the task definitions include: a compute component task definition including a compute component command and a corresponding compute task argument to assign a server blade among a pool of server blades on compute component **114**; a storage task definition including a storage component command and a corresponding storage task argument to create a storage volume on storage component **110**; and a network task definition including a network component command and a corresponding network task argument to establish a network pool and address range on network component **112**. Then a script may be generated to call the compute, storage, and network task definitions to configure the storage, network, and compute components, respectively.

Package Design Unit Menus

With the above detailed description of task definitions, tasks, and scripts as context, the manner in which PU **260** may be controlled by the user to select and perform operations on CI **106** is now described in connection with FIGS. **12A-12D**. FIGS. **12A-12D** depict example PU model menus (and associated model tasks) that may be displayed when CI Controller **108** invokes PU **260** under user control (e.g., at operation **345** of FIG. **3**) to execute the tasks in the PU. The term "menu(s)" means any prompt or list of prompts displayed to the user and through which the user may make a selection or enter information.

FIG. **12**A is an illustration of an example inventory task menu **1200**A that may be displayed when the user invokes PU **260**. Menu **1200**A lists exemplary inventory tasks by corresponding task IDs (e.g., Serial Number, Port list and status, and Neighbor Status). Each of the task IDs is associated with an underlying inventory task in Inventory Task Model **604** of PU **260**. When the user selects a given task by task ID from menu **1200**A, the associated underlying task is invoked, i.e., executed, to solicit the required information (e.g., Serial Number) from a targeted one of CI components **110-116**.

FIG. **12**B is an illustration of an example assessment task menu **1200**B that may be displayed when PU **260** is invoked. Menu **1200**B lists exemplary assessment tasks by task ID (e.g., Software Version, Device Model, license). Each of the task IDs is associated with an underlying task in Assessment Task Model **606** of PU **260**. When the user selects a given task by task ID from menu **1200**B, the associated underlying task is invoked to assess/validate a given aspect (e.g., Software Version) of a targeted one of CI components **110-116**.

FIG. **12**C is an illustration of an example configuration task menu **1200**C that may be displayed when PU **260** is invoked. Menu **1200**C lists exemplary configuration tasks by task ID (e.g., Aggregate Creation, Volume Creation, Volume Export). Each of the task IDs is associated with an underlying task in Configuration Task Model **608** of PU **260**. When the user selects a given task by name from menu **1200**C, the associated underlying task is invoked to configure a targeted one of CI components **110-116**, e.g., to create a storage volume on storage component **110**.

FIG. **12**D is an illustration of an example UI model menu **1200**D that may be displayed when PU **260** is invoked. Menu **1200**C lists exemplary information to be solicited from the user (e.g., Disk size, World Wide Port Name (WWPN) Start Address, Media Access Control (MAC) Pool size, etc.). When the user enters the prompted information, UI model **612** of PU **600** provides the entered information to the appropriate other model in the PU.

Generating a PU

With reference to FIG. **13**, the manner in which operations **335** and **340** of FIG. **3** cooperate to generate PU **260** is now described. FIG. **13** depicts relationships between operations **335** and **340**, task definition library **270**, and PD **256** used to generate a portion of PU **260**, namely, Inventory Task Model **604**. Initially, operation **335** selects those task definitions among task definitions **402-406** that are supported by the operating configurations of storage, network, compute, and virtualization components **110-116** as defined in corresponding ones of storage, network, compute, and virtualization component configuration definitions **502-508** of PD **256**. This can be thought of as mapping component configuration definitions **502-508** of PD **256** to selected ones of the task definitions **402-406**. In the example of FIG. **3** to generate Inventory Task Model **604**, such mapping is indicated as left-pointing arrows connecting component configuration definitions **502-508** to corresponding selected ones of task definitions of inventory task definition **402**.

Operation **340** then compiles the inventory, assessment, and configuration tasks selected or mapped by operation **335** into corresponding ones of Task Models **604-608** of PU **260**. In the example of FIG. **13**, operation **340** compiles all of the selected inventory task definitions into Inventory Task Model **604**. This compilation is indicated as a downward pointing arrow in FIG. **13**. The example depicted in FIG. **13** is extended to map PD definitions **502-508** to selected ones of assessment task definitions **404** and compile the selected assessment task definitions into Assessment Task Model **606**. The example is further extended to map PD definition **502-508** to selected ones of configuration task definitions **406** and compile the selected configuration tasks into Configuration Task Model **608**.

CI Controller Provisioning Engine

FIG. **14** is a block diagram of an example configuration **1400** of Provisioning Engine logic **256**. Configuration **1400** is also referred to herein as provisioning engine **1400**. Provisioning engine **1400** provides a logical framework within which PU models **408**-**412** may operate when PU **400** is invoked at operation **345** of FIG. **3**, for example. Configuration engine **1400** includes an inventory framework **1402**, an assessment framework **1404**, a configuration framework **1406**, and a configuration backup **1408** to host and interact respectively with Inventory Task Model **404**, Assessment Task Model **406**, Configuration Task Model **408**, and UI Model **412** of PU **400**. Provisioning engine **1400** also includes a neighbor discover framework **1410**.

Provisioning engine **1400** includes component/device communication drivers C I/F **1412**, S I/F **1414**, N I/F **1416**, and V I/F **1418** to support communications (of the PU model tasks) respectively with compute component **114**, storage component **110**, network component **112**, and virtualization component **116** through a transport framework **1419**. Provisioning engine **1400** also includes a generalized framework **1420** through which the various PU models hosted in the corresponding frameworks may inter-communicate, and a GUI **1422** to support PU model interaction with the user as described above.

CI Design Blueprint and Generation of Task Definitions

As described above, task definition library **270** includes many task definitions from which appropriate task definitions are selected for incorporation into PU **260**. The many task definitions in task definition library **270** may be generated from a blueprint of a CI design, as is now described. With reference to FIG. **15**, there is depicted an excerpt from an example human readable CI design blueprint **1500** for FlexPod™ from which task definitions may be generated. The excerpt includes a sequence of line items that together form an outline or table of contents for the blueprint. That is, each line item listed is associated with further descriptive text and graphics of the blueprint not shown in FIG. **15**. Collectively, the line items listed in FIG. **15** and the associated further description provide information on how to configure the storage, network, compute, and virtualization components in accordance with a validated design represented by the blueprint.

The process to generate tasks ("generate-tasks-process") from the blueprint receives the blueprint as an input. The process also receives vendor provided interface data models, i.e., specifications, for each of the storage, network, compute, and virtualization components of the CI. The interface data models define task definitions with tasks/commands to interact with and perform operations on targeted ones of the CI components.

In an initial operation, the generate-tasks-process associates each of the line items in blueprint **1500** and its associated underlying description with a corresponding one of assumed CI components and, correspondingly, with the data model for that CI component. As an example, the task generate process associates: (i) storage-related line items **1510** (and the associated underlying description) with the CI storage component (e.g., storage component **150** of CI **106**), and correspondingly with the storage component interface data model; (ii) network related line items **1512** with the CI network component (e.g., network component **152**) and its related data model; (iii) compute line items **1514** with the CI compute component and its related data model; and (iv) virtualization related line items **1516** with the CI virtualization component and its related data model.

As just mentioned, the initial operation associates the line items of the blueprint with appropriate corresponding component data models. A result is that the line items are now correspondingly mapped to the vendor defined task definitions available in the associated data models.

In a next operation, the generate-tasks-process maps each of the line items to one or more of inventory, assess, and provision/configure activities based on the subject matter addressed by the line item and its underlying description. After this operation, the task definitions already associated with the line items are now correspondingly associated with the one or more activities.

In a next operation, the task-generate-process populates task definition library **270** with mapped task definitions (as determined in the previous operation).

The techniques presented herein advantageously automate and simplify for the user a deployment of a CI, which has initially unknown hardware and/or software component configurations. One technique automatically determines actual hardware and/or software configurations of the CI components while the CI components are operating and stores the determined configurations in a pod descriptor. The technique automatically generates a package design unit from the pod descriptor that may be invoked by the user to perform operations on the CI components. The package design specification accurately reflects the actual configuration of the CI components because it was generated based on the pod descriptor and, therefore, is fully supported by the CI components.

In summary, in one form, a method is provided, comprising automatically collecting component configuration information from and representative of operating storage, compute, and network components of a converged infrastructure (CI); constructing a pod descriptor including operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information; generating a package specification unit based on the component configuration definitions of the pod descriptor, the package specification unit including tasks that, when executed, automatically inventory, assess, and configure targeted ones of the CI components; and executing the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

In another form, an apparatus is provided, comprising: a network interface unit configured to send and receive communications over a network; and a processor coupled to the network interface unit, and configured to: automatically collect component configuration information from and representative of operating storage, compute, and network components of a converged infrastructure (CI); construct a pod descriptor including operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information; generate a package specification unit based on the component configuration definitions of the pod descriptor, the package specification unit including tasks that, when executed, automatically inventory, assess, and configure targeted ones of the CI components; and execute the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

In still another form, a processor readable medium is provided. The processor readable medium stores instructions that, when executed by a processor, cause the processor to: automatically collect component configuration information from and representative of operating storage, compute, and network components of a converged infrastructure (CI); construct a pod descriptor including operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information; generate a package specification unit based on the component configuration definitions of the pod descriptor, the package specification unit including tasks that, when executed, automatically inventory, assess, and configure targeted ones of the CI components; and execute the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

Although the method, apparatus, and computer program product/processor readable medium are illustrated and described herein as embodied in one or more specific examples, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the scope of the apparatus, system, and method and within the scope and range of equivalents of the claims. Accordingly, it is appropriate that the appended claims be construed broadly and in a manner consistent with the scope of the apparatus, system, and method, as set forth in the following claims.

What is claimed is:

1. A method comprising:

collecting component configuration information from and representative of operating storage, compute, and network components of a converged infrastructure (CI);

constructing a pod descriptor including operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information;

generating a package specification unit based on the component configuration definitions of the pod descriptor, the package specification unit including tasks that, when executed, automatically inventory, assess, and configure targeted ones of the CI components; and

executing the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

2. The method of claim **1**, wherein the constructing the pod descriptor includes:

prompting a user for customizable component configuration information through a graphical user interface;

receiving customized component configuration information entered manually through the graphical user interface; and

writing the automatically collected and the manually entered component configuration to corresponding ones of the storage, compute, and network component configuration definitions of the pod descriptor.

3. The method of claim **2**, wherein the generating a package specification unit includes:

selecting the inventory, assess, and configure tasks from a library of tasks based on the component configuration definitions of the pod descriptor so that the tasks are supported on the CI components; and

compiling the selected inventory, assess, and configure tasks into inventory, assessment, and configuration task models of the package design specification.

4. The method of claim **3**, wherein the executing includes executing the tasks in the package specification unit to inventory, assess, and configure targeted ones of the CI components.

5. The method of claim **3**, wherein each task is part of a corresponding task definition that includes:

a task identifier (ID);

the task represented as one or more component readable commands each to perform a corresponding operation on a targeted component when the task is executed; and

one or more task arguments through which one or more component related parameters are passed to the commands and to the targeted component when the task is executed,

wherein executing the task includes providing the commands therein and the passed component related parameters to the targeted CI component.

6. The method of claim **1**, wherein the collecting includes collecting from at least some of the CI components: a component model number; a component serial number; a software version; a number and a type of external interface ports; and a number and type of memory cards that are supported.

7. The method of claim **1**, wherein:

the collecting further includes collecting component configuration information from and representative of a virtualization component of the CI; and

the generating further includes generating a virtualization component configuration definition in the pod descriptor based on the collected virtualization component configuration information.

8. An apparatus comprising:

a network interface unit configured to send and receive communications over a network; and

a processor coupled to the network interface unit, and configured to:

collect component configuration information from and representative of operating storage, compute, and network components of a converged infrastructure (CI);

construct a pod descriptor including operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information;

generate a package specification unit based on the component configuration definitions of the pod descriptor, the package specification unit including tasks that, when executed, inventory, assess, and configure targeted ones of the CI components; and

execute the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

9. The apparatus of claim **8**, wherein the processor is configured to construct the pod descriptor by:

prompting a user for customizable component configuration information through a graphical user interface;

receiving customized component configuration information entered manually through the graphical user interface; and

writing the collected and the manually entered component configuration to corresponding ones of the storage, compute, and network component configuration definitions of the pod descriptor.

10. The apparatus of claim **9**, wherein the processor is configured to generate the package specification unit by:

selecting the inventory, assess, and configure tasks from a library of tasks based on the component configuration definitions of the pod descriptor so that the tasks are supported on the CI components; and

compiling the selected inventory, assess, and configure tasks into inventory, assessment, and configuration task models of the package design specification.

11. The apparatus of claim **10**, wherein the processor is configured to execute the tasks in the package specification unit to inventory, assess, and configure targeted ones of the CI components.

12. The apparatus of claim **10**, wherein each task is part of a corresponding task definition that includes:

a task identifier (ID);

the task represented as one or more component readable commands each to perform a corresponding operation on a targeted component when the task is executed; and one or more task arguments through which one or more component related parameters are passed to the commands and to the targeted component when the task is executed,

wherein the processor configured to provide the one or more commands therein and the passed component related parameters to the targeted CI component.

13. The apparatus of claim **8**, wherein the processor is configured to collect from at least some of the CI components: a component model number; a component serial number; a software version; a number and a type of external interface ports; and a number and type of memory cards that are supported.

14. The apparatus of claim **8**, wherein the processor is configured to:

collect component configuration information from and representative of a virtualization component of the CI; and

generate a virtualization component configuration definition in the pod descriptor based on the collected virtualization component configuration information.

15. A non-transitory processor readable medium storing instructions that, when executed by a processor, cause the processor to:

collect component configuration information from and representative of operating storage, compute, and network components of a converged infrastructure (CI);

construct a pod descriptor including operating storage, compute, and network component configuration definitions for the CI based on the collected component configuration information;

generate a package specification unit based on the component configuration definitions of the pod descriptor, the package specification unit including tasks that, when executed, inventory, assess, and configure targeted ones of the CI components; and

execute the tasks in the package specification unit to perform corresponding operations on targeted ones of the CI components.

16. The processor readable medium of claim **15**, wherein the instructions to cause the processor to construct the pod descriptor include instructions to cause the processor to:

prompt a user for customizable component configuration information through a graphical user interface;

receive customized component configuration information entered manually through the graphical user interface; and

write the collected and the manually entered component configuration to corresponding ones of the storage, compute, and network component configuration definitions of the pod descriptor.

17. The processor readable medium of claim **16**, wherein the instructions to cause the processor to generate the package specification unit include instructions to cause the processor to:

select the inventory, assess, and configure tasks from a library of tasks based on the component configuration definitions of the pod descriptor so that the tasks are supported on the CI components; and

compile the selected inventory, assess, and configure tasks into inventory, assessment, and configuration task models of the package design specification.

18. The processor readable medium of claim **17**, wherein the instructions to cause the processor to execute include instructions to cause the processor to execute the tasks in the package specification unit to inventory, assess, and configure targeted ones of the CI components.

19. The processor readable medium of claim **17**, wherein each task is part of a corresponding task definition that includes:

a task identifier (ID);

the task represented as one or more component readable commands each to perform a corresponding operation on a targeted component when the task is executed; and

one or more task arguments through which one or more component related parameters are passed to the commands and to the targeted component when the task is executed,

wherein the instructions to cause the processor to execute the task include instructions to cause the processor to provide the one or more commands therein and the passed component related parameters to the targeted CI component.

20. The processor readable medium of claim **15**, wherein the instructions to cause the processor to collect include instructions to cause the processor to collect from at least some of the CI components: a component model number; a component serial number; a software version; a number and a type of external interface ports; and a number and type of memory cards that are supported.

21. The processor readable medium of claim **15**, wherein:

the instructions to cause the processor to collect includes instructions to cause the processor to collect component configuration information from and representative of a virtualization component of the CI; and

the instructions to cause the processor to generate include instructions to cause the processor to generate a virtualization component configuration definition in the pod descriptor based on the collected virtualization component configuration information.

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